ASEAN Journal of Science and Engineering Education

Journal homepage: http://ejournal.upi.edu/index.php/AJSEE/

A Multi-USB Ports Solar-powered charging Station for Mobile Phones in Duracurve Sheds: From Educational Perspectives

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ABSTRACTS

The current study proposed a design for a Multi-USB Ports Solar-powered charging Station for Mobile Phones in Duracurve Sheds of Don Honorio Ventura State University. This research specifically aimed at addressing the issue of prohibiting the students of electrical engineering at Don Honorio Ventura State University (DHVSU) to charge their mobile phones inside the classrooms. This study, as quantitative research, utilized a developmental type of method, a Likert scale type of questionnaire through electronically generated forms (google form), and a thorough data analysis. The participants were composed of twenty (20) professionals and were chosen through the use of the purposive sampling technique. The study revealed that the proposed design for the solar-powered charging station, after considering its specifications, the materials and possible cost of its installation, its expected lifespan, and the total expenditure it will take could be an alternative way to provide a solution for each student's concern, especially for educational purposes.

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ARTICLE INFO

Article History:
Submitted/Received 24 May 2022
First revised 27 Jun 2022
Accepted 07 Jul 2022
First available online 08 Jul 2022
Publication date 01 Sep 2023

Keyword:
Charging,
Design,
Developmental,
Lifespan,
Likert,
Mobile,
Quantitative,
Solar.

1. INTRODUCTION

The primary energy components in our world today come from sources such as coal, petroleum, and other fossil fuels. Utilizing solar-powered electricity is one of these energy sources (Ike *et* al., 2014). Renewable energy may be utilized to generate electricity; the sun's energy can be used to heat fluids for turbines in solar thermal systems or turned directly to electricity using photovoltaic principles (Psomopoulos, 2013). Oil price increases increased awareness of energy-related pollution, and the negative consequences of climate change have all contributed to a re-evaluation of energy consumption. This re-evaluation has resulted in increased energy efficiency in industry and electricity generation, as well as lighting, home appliances, and transportation.

The efficient use of energy is a major factor that contributes to the improvement of energy consumption that has occurred in the last decades in almost all industrialized countries. According to Maroma (2014), these phone chargers will become more common as solar-powered electricity becomes more widespread. Non-renewable energy sources and fossil fuels are a thing of the past. Suppose not having to use an electrical outlet to charge your phone, but instead being able to use the sun's energy to capture it. By this, it can save money, the usage of energy will become more efficient, and the source coming from the sun is significant to use rather than an outlet. Mobile phones are now the most widely used electronic device in practically every country in the world Rao (2019).

According to the International Telecommunication Union, there are over 6.8 billion cell phone users worldwide, and the number is rapidly increasing as technology improves and production costs fall. The cell phone is one of the most common means of communication today and through advancements in technology, is also one of the most affordable electronic gadgets that one can avail (Papadakis *et al.,* 2018). Many systems and gadgets have been incorporated into mobile phones, transforming them into multifunctional devices capable of processing photographs, emails, and other data.

Moreover, as stated by Maroma (2014), cell phones rely on electric current to carry out their many functions and they require to be charged every so often. Hence, to address the issue of prohibiting the students of electrical engineering to charge their mobile phones inside the classrooms, we opted to propose a design of Multi-USB Ports Solar-powered charging Station for Mobile Phones in Duracurve Sheds of Don Honorio Ventura State University.

2. METHOD

This section includes the research methods, the description of the respondents, procedures for gathering data, the population, research instruments, and the techniques used in performing the study. Since the questions in the survey will be answered by twenty (20) professionals to apply the appropriate treatment to incoming results from the data, the study was determined as quantitative research (see **Figure 1**). We used a developmental type of research to achieve the study's developed objective. It is widely used in the analysis of the product development process, which is appropriate to the study since the output is the design of a multi USB port solar-powered charging station. In the world of instructional technology, developmental research is very important. The main data gathered from the respondents' assessment of the administered questionnaire was tallied, organized, analyzed, and interpreted through the use of the most appropriate statistical procedures. Also, a Likert scale will be used in the scoring method for analyzing people's opinions, attitudes, and behaviors. Likert scales are common in survey research because they make it easy to operationalize

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

personality traits or perceptions. Through that, we came up with the design of the solar-powered charging station as shown in **Figure 2**.

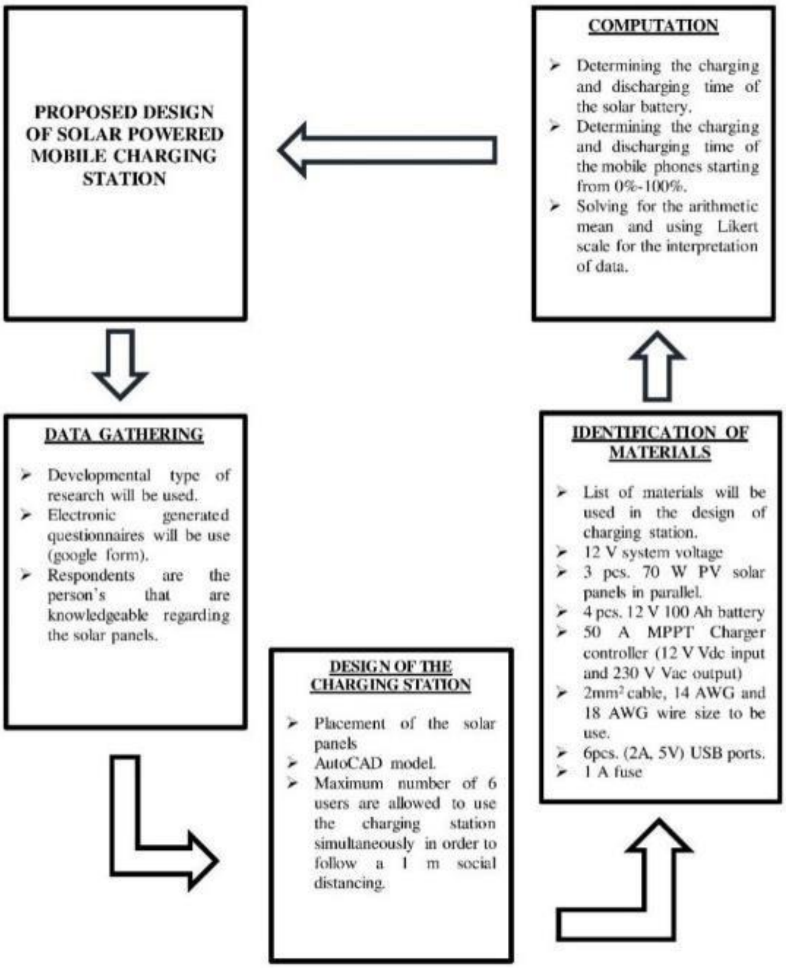

Figure 1. Research procedure of the study.

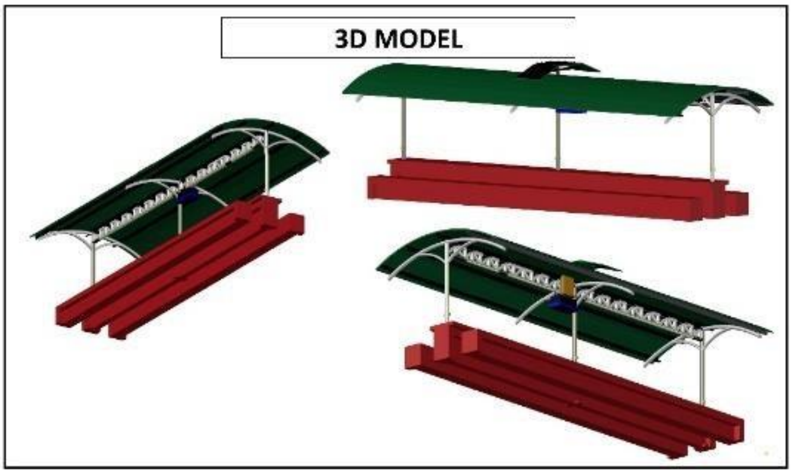

Figure 2. Proposed AutoCAD design of the solar-powered charging station.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

The list of materials that will be used in the proposed design of the charging station is based on the questionnaire that was utilized to gather data (see **Figure 3**), and these are the following: 12 V system voltage, three 70 W photovoltaic (PV) solar panels connected in parallel to collect energy from the sun and produce electrical power, four 12V 100 Ah batteries to store excess electricity generated by the solar panels, a 50 A Maximum PowerPoint Tracking (MPPT) charger controller (12-Vdc input and 230-Vac output), and six 2A, 5V USB ports. With the aforementioned equipment, we have to determine the placement of the solar panels and the acceptability of materials in terms of solar panel wattage and battery, the type of USB ports for charging phones, the possible cost, and the lifespan of the solar charging station based on the information that will be given by the experts. More importantly, the target number of users in the proposed design will be six (6) people at a time to maintain social distance.

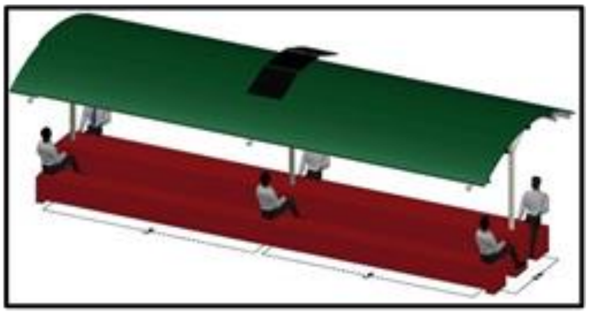

Figure 3. Proposed AutoCAD design of the solar-powered charging station that shows the social distancing between the users.

Several equations are used, which are described in the following:

(i) Equation (1) is the charging time of the battery

$$CT = \frac{Ah}{I} \quad (1)$$

where *CT* is charging time in hours, *Ah* is battery capacity in Ampere hour, and *I* generated current in Ampere (A).

(ii) Equation (2) is the discharging time of the battery

$$DT = \frac{Battery\ (Ah) x\ Battery\ (V)}{L} \quad (2)$$

where *DT* is discharging time in hours, *Battery Ah* is Battery capacity in Ampere-hour, *Battery V* is the voltage produced of the battery, and *L* is applied load in watts.

(iii) Equation (3) is the Computation for the total wattage of solar panels

$$Solar\ Panel\ Wattege = \frac{(Total\ watt{-}hours\ per\ day)(Energy\ loss\ in\ the\ system)}{Panel\ Generation\ Factor} \quad (3)$$

where solar panel wattage is the solar panel size that is required in the system, total watt-hours per day is the expected load present in the system in Watt-hour, and energy loss in the system is the expected loss factor when the light energy is converted to electrical energy and has a constant value of 1.3 and is unit less and Panel generation factor is automatically used in the computation of solar panel sizing that is a varying factor that is dependent to the climate of a country. In the Philippines, the panel generation factor is 3.43 and is a unit less.

(iv) Equation (4) is the Computation for the size of solar panels (S.S.P)

$$S.S.P = \frac{Total\ Solar\ Panel\ Wattage}{Number\ of\ solar\ panel\ to\ be\ used} \quad (4)$$

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p- ISSN 2775-6793 e- ISSN 2775-6815

where total solar panel wattage is the solved value derived from Eq. (3) and the number of solar panels to be used is the number of panels suggested for the design for mixed light conditions.

(v) Equation (5) is the Computation for the battery capacity

$$Battery\ Capacity\ (Ah) = \frac{Total\ Watt{-}hours\ per\ day\ used\ x\ Days\ of\ autonomy}{(0.85\ \times 0.6\ nominal\ battery\ voltage)} \quad (5)$$

where total watt-hours per day are the expected load present in the system in Watt-hour, days of autonomy is the number of days that the battery can last without any support from a generation source. In this study, we used 4 days. 0.85 is the battery loss in the system, 0.6 is the depth of discharge in the system and Nominal battery voltage is the voltage of the battery when delivering its rated capacity in a specific discharging rate. We used 12 V.

(vi) Equation 6 is the Computation for the current size

$$Solving\ for\ the\ current\ size = \frac{Total\ Watt{-}hours\ per\ day}{Expected\ voltage\ output} \quad (6)$$

where total watt-hours per is expected load present in the system in Watt-hour and expected voltage output ss the voltage set to be produced in the system its unit is in volts (V).

(vii) Equation (7) is the Solar panel tiltation angle

$$Solar\ Panel\ Tilt\ Angle = Latitude\ \times 0.87 \quad (7)$$

Here is the list of statistical tools done in presenting the data

(i) Equation (8) is the formula of weighted mean as follows is the

$$fx = (f)(x) \quad (8)$$

where *fx* is weighted mean, *f* is frequency and *x* are scale.

(ii) Equation (9) is the formula for an average weighted mean is as follows is the

$$\bar{x} = \frac{\sum Fx}{\sum F} \quad (9)$$

where $\bar{x}$is average weighted mean, *F* is frequency, $\sum F$ is the total number of respondents, and $\sum Fx$ summation of weighted mean.

(iii) Equation (10) is the Percentage

$$P = \frac{f}{N} \times 100 \quad (10)$$

where *P* is the percentage, *f* is the frequency of each variable, and *N* is the total number of populations. Adopted from is the Indeed, Editorial Team, (2022), How to Calculate percentage in three easy steps.

The rating of the area means comes within the reliable and legitimate answers of the respondents that correspond to the transportation indicators. Likert Scale. Likert Scale measures the degree of response from the area mean on each item. Equation (11) is the population standard deviation.

$$\sigma = \sqrt{\frac{\sum(x_i - x)^2}{N}} \quad (11)$$

where $\sum$ is summation, x_i is Each value of the population, x is the average weighted mean, and N is the total number of populations.

Table 1 shows the 5-point Likert scale categories for response levels with verbal descriptions. There are 5 scales, namely Highly Acceptable, Acceptable, Moderately Acceptable, Unacceptable, and Highly Unacceptable.

Table 1. The category of the 5-point liker scale for the level of responses with its verbal description.

SCALE	Verbal Interpretation
4.00 - 5.00	Highly Acceptable
3.00 - 3.99	Acceptable
2.00 - 2.99	Moderately Acceptable
1.00 - 1.99	Unacceptable
0 - 0.99	Highly Unacceptable

3. RESULTS AND DISCUSSION

This section was used to calculate how long the battery of the solar panel and mobile phone will be fully charged and how long it will take to discharge to 0%. Equation (1) was the formula used for the charging time and Eq. (2) was used in determining the discharging time.

3.1. Demographic Profile of the Respondents

According to the results gathered, seventeen (85%) of the respondents were male while three (15%) of the respondents were female. Lastly, none (0%) among them answered prefer not to say (see **Figure 4**).

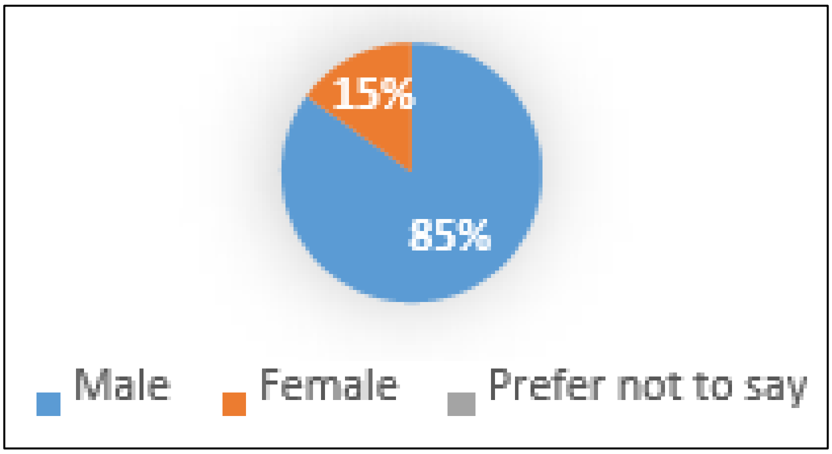

Figure 4. Summary of the percentage distribution of the respondents according to gender.

As shown in **Figure 5**, eight (40%) of the respondents were aged 20-25 years old and the same data was achieved for 26-30 years old. Three (15%) of the respondents fall under 31-35 years of age. On the other hand, none of the respondents were 36-40 years old, and lastly one among the twenty informants whose ages fall between 41-45 years old.

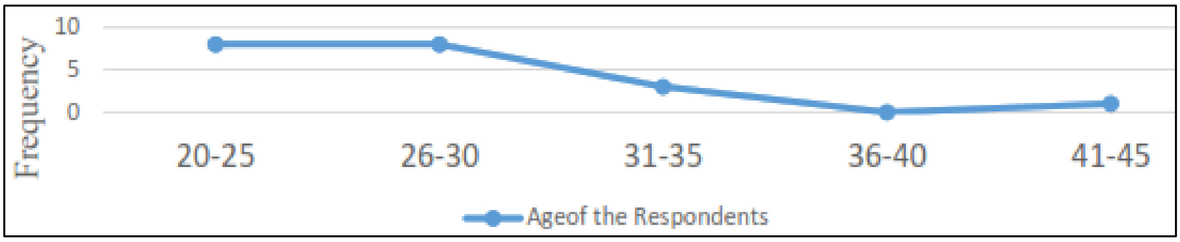

Figure 5. Summary of the frequency distribution of the respondents according to age.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

As shown in **Figure 6**, all respondents answered that they have knowledge or expertise regarding solar panels. While among them, none answered no. That validates the informants chosen for the study will have reliable and concrete information regarding the study since they do have proficiency in solar panels.

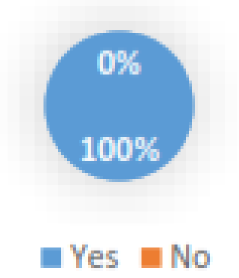

Figure 6. Respondents answer if they have knowledge or expertise regarding solar panels.

3.2. Research Questionnaire

The research question 1 to 7 are shown in **Figures 7-13**. The findings show that ten (50%) of respondents selected extremely satisfactory. Out of twenty respondents, six gave satisfactorily and three gave somewhat acceptable responses, accounting for 30 and 15% of the total. One of them (5%) replied severely unacceptable, while none of them answered unacceptably. With an average weighted mean (AWM) of 4.20, it can be concluded that the solar panel's physical compatibility with the Don Honorio Ventura State University's duracurve sheds in the suggested AutoCAD design is quite acceptable. The obtained standard deviation for this query is 1.03 as well.

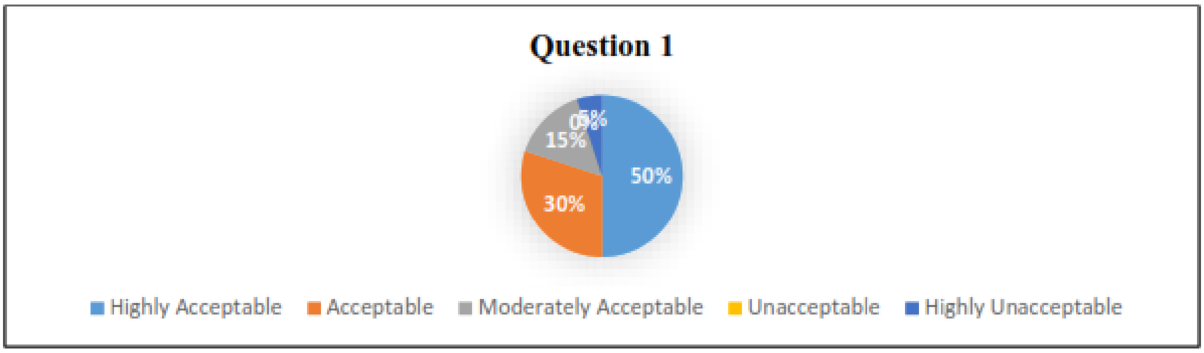

Figure 7. Summary of the respondents' answers regarding the acceptability of the AutoCAD design model.

The results gathered from the survey state that five (25%) of the respondents said that the proposed size of solar panels is highly acceptable. Thirteen (out of twenty respondents (65%) state that it is acceptable. Two answered that it is moderately acceptable. None of them answered unacceptable and highly unacceptable. An AWM of 4.15 is calculated which means that the three pieces of 70-W solar panels are highly acceptable for the design to deliver enough energy to charge 6 mobile phones simultaneously. In addition, the acquired standard deviation for this question is 0.572.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

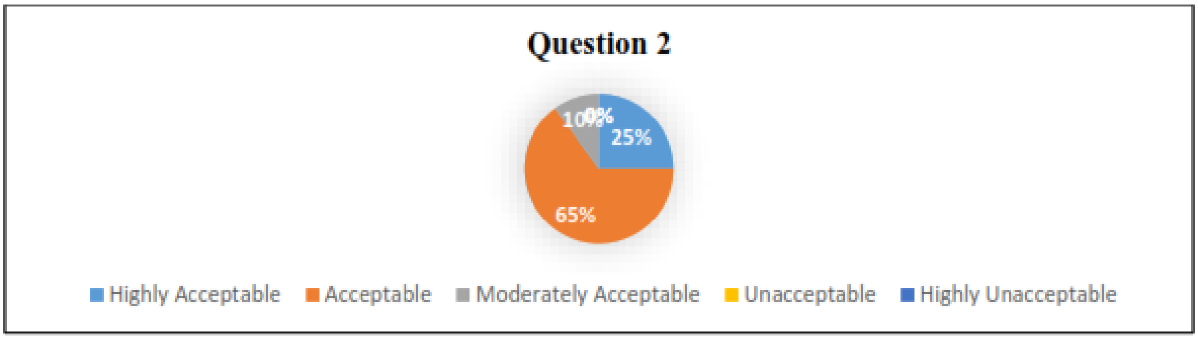

Figure 8. Summary of the respondents' answers regarding the acceptability of the proposed solar panel specifications.

Regardless of whether you're utilizing a tiny solar system or charging your second battery using a battery isolator, we have found that 100-amp hours offer the optimum energy and price combination for the ordinary van dweller. For charging cell phones and tablets, LED lighting, and small accessories, inverters are frequently adequate. Applications for energy storage are numerous. However, small to medium-sized appliances are routinely powered by standard 12 V and 100 Ah batteries in a variety of locations, including boats and campers. Some people build up a parallel connection of 12V 100Ah batteries to store extra energy produced by their off-grid solar panel systems.

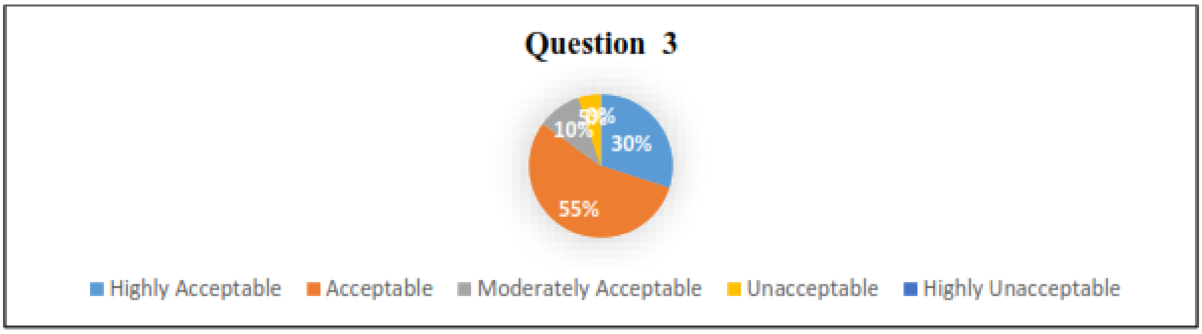

Figure 9. Summary of the respondents' answers regarding the acceptability of the proposed battery specifications.

The results revealed that eight (40%) of the respondents answered highly acceptable. Out of twenty respondents, eleven (55%) answered acceptably and one (5%) answered moderately acceptable. None of them (0%) responded unacceptably and the remaining and similar respond as highly unacceptable.

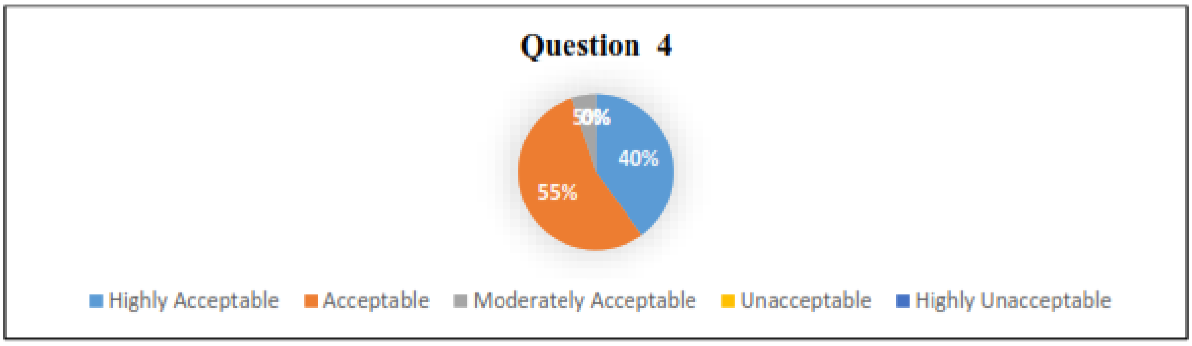

Figure 10. Summary of the respondents' answers regarding the acceptability of the proposed USB port specifications and the MPPT charger controller.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

The result of this question showed that four (20%) of the participants responded Highly Acceptable. Fourteen (70%) of them responded Acceptably, 5% answered Moderately Acceptable, and 5% also answered Unacceptably. None of them responded Highly Unacceptable. In addition, the acquired standard deviation for this question is 0.669.

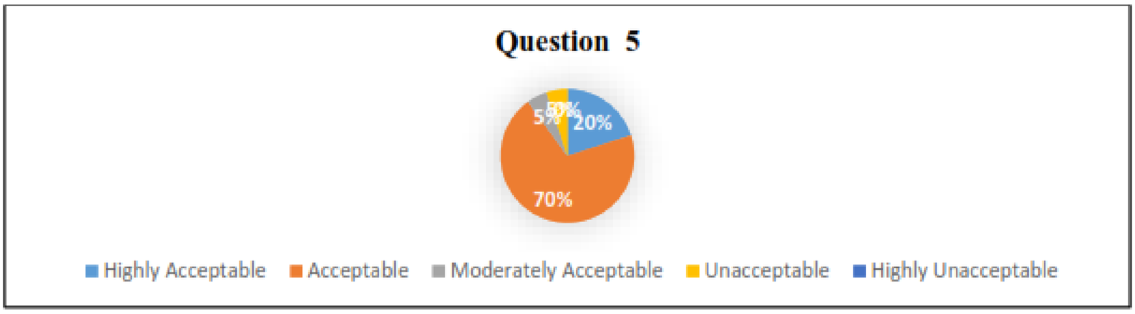

Figure 11. Summary of the respondents' answers regarding the acceptability of the proposed wire sizes.

The results revealed that five (25%) of the respondents answered Highly Acceptable, 12 of them responded Acceptably, 15% of them retorted to Moderately Acceptable, and none (0%) participants responded to Unacceptable and Highly unacceptable options.

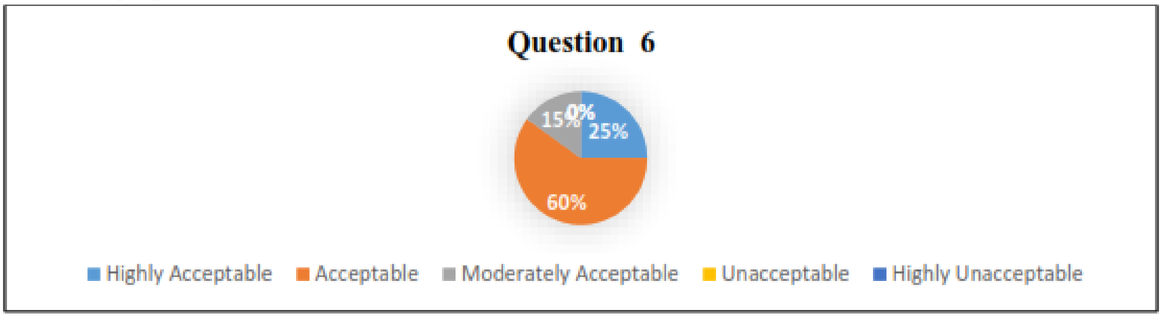

Figure 12. Summary of the respondents' answers regarding the acceptability of the possible cost of the solar charging station.

Presented in **Figure 13**, a totality of seven (35%) respondents answered Highly acceptable, six (30%) of them retorted to Acceptable, another six (30%) of them responded Moderately Acceptable, one (5%) of them responded to Unacceptable, and none (0%) from them answered Highly unacceptable.

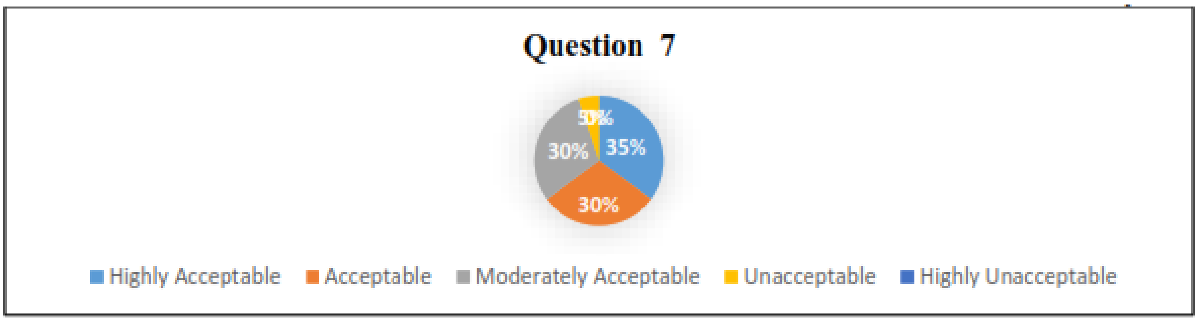

Figure 13. Summary of the respondents' answers regarding the acceptability of the expected life span of the solar charging station.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

4. CONCLUSION

In this study, we proposed the design of a solar-powered mobile charging station for students and guests at Don Honorio Ventura State University using AutoCAD Application Software. Solar energy was considered in producing a charging station that would allow users to charge their devices quickly. We concluded that the solar-powered charging station could be an alternative way to provide a solution for each user's concern, especially for educational purposes.

5. ACKNOWLEDGMENTS

We would like to express our deepest gratitude to the following for making this thesis possible To our family members and friends, our earnest gratitude to them for the motivation and love, for the infinite support and guidance, we share the joy and pride to all of you and lastly, ourselves, for the team effort, patience, and encouragement to each other during the tough times, the endless understanding for each and everyone's shortcomings to finish this humble undertaking.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815